AUG 13 1932

Volume 18 August, 1932 *Number 8*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

The Foundation of Effective Lubrication

The Importance of Design and Installation

PUBLISHED BY
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Published by
The Texas Company, 135 East 42nd Street, New York City
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Vol. XVIII August, 1932 No. 8

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The Foundation of Effective Lubrication

The Importance of Design and Installation

THE necessity for cooperation between the machinery builder and the refiner of lubricants, in the interest of ultimately successful operation, has been forcibly realized over the past few years, until lubrication recommendations are frequently studied with quite as much care as are types of bearings and proposed methods of lubrication.

And rightly so, for effective and dependable lubrication can only be obtained by due consideration of operating conditions, the ability of available methods of lubricant application, and the specific characteristics of the wide variety of lubricants which may be subsequently offered, after the machine has gone into service.

The installation engineer plays a distinct part in the attainment of ultimately successful lubrication, by virtue of the extent to which he is responsible for absolute alignment, the condition and fit of the bearings, and the manner in which lubricating equipment is installed. It is essential to remember that initial satisfaction in the operation of any piece of machinery is of distinct advantage, not only to the builder but also to the manufacturer of the lubricants used over the try-out period.

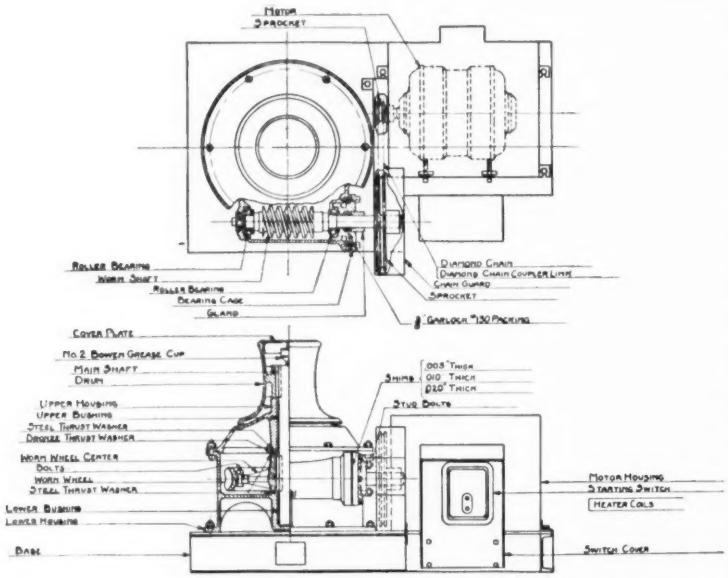
Development of any troubles due to misalignment, improper installation of bearings or the inability of the means of lubrication to deliver the necessary amount of lubricant, according to machine requirements, is all too often laid directly at the door of the manufacturer of the lubricants used.

The problem before the machinery builder in the interests of efficient operation of his equipment is, therefore, evident. Controversy relative to failure in operation, regardless of where the responsibility lies, is detrimental to all concerned, whether it be due to improper installation, faulty lubricating equipment, or the use of unsuitable lubricants. It is, therefore, highly essential that study of installation lubrication be extended beyond the drafting room, to include the installation personnel, for the installation or erecting engineer, in the case of large machinery, is a most important personage in the attainment of ultimately successful operation. His mechanical ability, his integrity and freedom from prejudice are vital factors.

THE RELATION OF MACHINE DESIGN

Effective lubrication of any type of mechanism begins in the drafting room, with the design of the parts involved and consideration of the method by which lubrication is to be accomplished. In the past there has been altogether too much tendency to regard lubrication as an after-thought, moving elements being designed with respect to their duty, and the function to be performed. Inadequate capacity of oil reservoirs, or improper location of points of lubricant application have borne witness to this many times over.

The modern machine designer, however, places the true value upon lubrication, to the extent that automatic lubrication is coming to be more and more accepted as a necessity, particularly where intricate mechanisms are involved, failure of which, due to abnormal wear, would entail considerable expense, loss of time, or interruption of production schedules. This latter is especially important to remember in an industry such as the automotive, where machinery operations are inter-related and where parts production is carried on by a wide variety of machinery, all functioning with respect to one another.



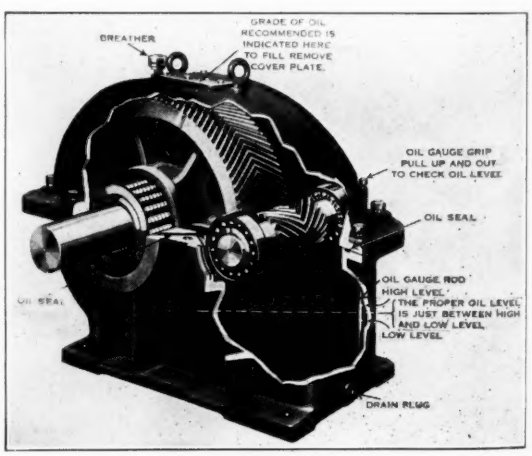
Courtesy of The Jeffrey Manufacturing Co.

Fig. 1—Detailed view of a Jeffrey car puller, showing constructional details of parts requiring lubrication.

The extent to which lubrication has been given consideration in connection with machine design has also been noteworthy in the development of the modern paper machine. Operating experience has dictated that this machine must function in as perfect alignment as possible, in order to produce maximum widths of paper without warped edges, and the minimum reduction in tonnage output. In other words, when extensive trimming of edges is necessary, due to faulty alignment or imperfect operation, the finished paper may not meet the width specification, entailing more or less waste before a usable size is obtained.

Bearing performance has been proved to be of decided importance in the operation of paper machinery and maintenance of alignment of the wire. To this end the paper mill designer has given the utmost consideration to the adoption of anti-friction bearings. Particular stress has been laid upon the adaptability of the roller bearing. By the use of these bearings it has been possible to design housings so as to eliminate much of the trouble previously experienced from entry of water, paper pulp, or other non-lubricating matter which may be around the machine. Certain types of housings also prevent abnormal leakage of lubricant on the drier end where comparatively high temperatures may prevail, due to the use of steam for heating purposes.

The steel mill designer has also given most careful thought to bearing design. Roll necks in particular have received serious attention. Until recently the open sleeve type bearing has prevailed in steel mill operations. Of late, however, the roller bearing has been studied and actual installations have been claimed to prove its adaptability, not only from the viewpoint of reduced maintenance cost, but also ease of lubrication. Whether or not the roller bearing will continue its advancement will depend to an extent upon the developments in sleeve type bearing composition and the extent to which certain comparatively new compounds will meet the rigors of continuous operation, and the amount of wear developed.


Breather
Grade of oil recommended is indicated here. To fill remove cover plate.
Oil gauge grip pull up and out to check oil level
Oil seal
Oil gauge rod
High level
The proper oil level is just between high and low level.
Low level
Oil seal
Drain plug

Courtesy of Foote Brothers Gear and Machine Co.

Fig. 2—Phantom view of a Foote herringbone reduction gear, showing constructional details pertinent to lubrication.

The claim is being made that lubrication of the newer types of steel mill sleeve type bearings can be effected as satisfactorily and as economically as that of the roller bearings.

It is, therefore, obvious that the designing

engineer should be intimately conversant with bearing developments as they may pertain to lubrication in making original lay-outs for virtually any type of machinery. Judicious choice of means of lubrication, commensurate with the requirements of operation, will make it possible to design a machine capable of efficient, economical lubrication and operation.

Where it is impossible to prevent a machine from coming in contact with abrasive foreign matter, the designer may be justified in not giving it the same care as he would to a device which can be installed apart from dust or dirt, and the detrimental effects of water, or widely varying temperature conditions.

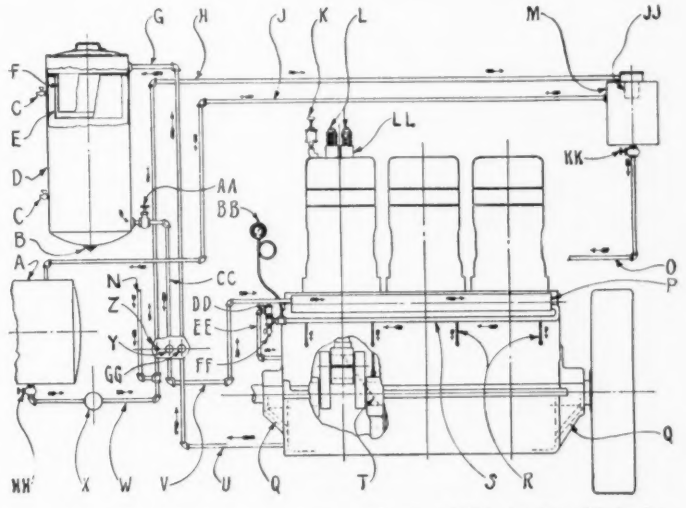
Certain types of machinery, such as the electric motor and some varieties of machine tools can be designed in such a dust-tight manner as to insure maintenance of quite as effective lubrication as can be secured where the above conditions do not exist. This has been materially aided by the development of the anti-friction bearing and the success achieved by the builders of such bearings in construction of dust guards and means of lubricant retention in the form of labyrinth, leather or grease seals.

Influence of Design Upon Lubricant Refinement

Design must therefore be given consideration in deciding upon the degree of refinement essential in a lubricant. Wherever the design of bearings, gears, chains or other moving parts is such that they must function comparatively exposed, if it is impracticable to prevent drip or waste, a cheaper grade of lubricant can normally be recommended than where such conditions do not exist.

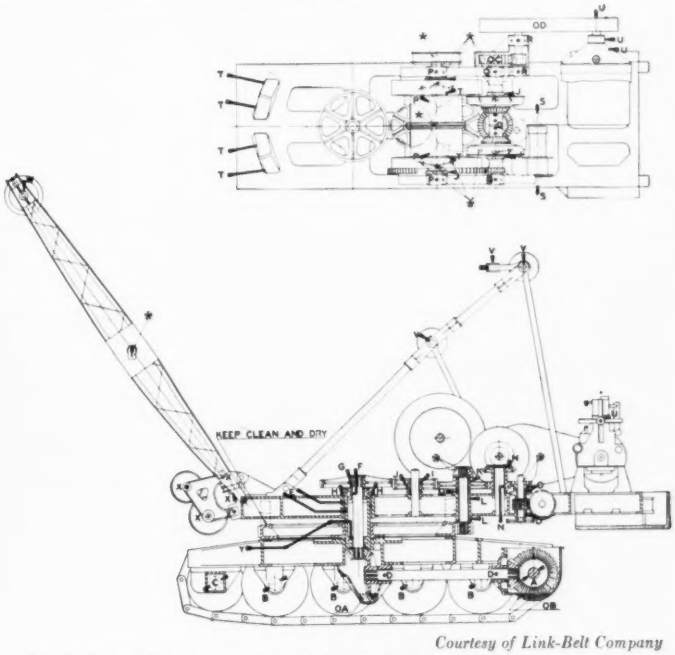
Such a lubricant may not possess the same lubricating ability as a more highly refined product; on the other hand, the use of the latter under such conditions would not be economical nor an assurance of any better lubrication, due to the fact that it might become unduly contaminated, with consequent reduction in its original lubricating ability. Furthermore, an initial high cost would not be justified where drip or premature waste cannot be prevented.

Where original design is such as to permit waste, it should not be accepted as inevitable. Every endeavor should be made to overcome it, if it can be accomplished without abnormal expense. This will be especially true under conditions which may cause contamination of lubricants during service.



Courtesy of Wolverine Motor Works, Inc.

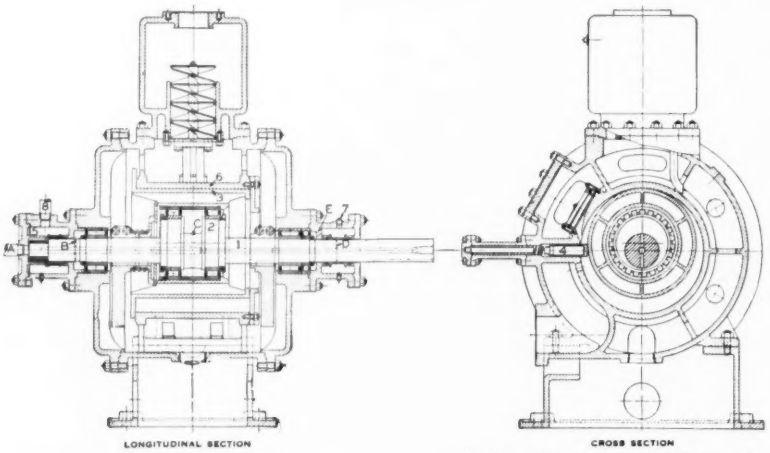
Fig. 4—Showing the lubricating system of a Wolverine Diesel engine. Manufacturer's instructions relative to the alphabetical key give operator adequate information as to lubrication requirements.



Courtesy of Link-Belt Company

Fig. 3—Lubricating diagram for a Link-Belt shovel-crane-dragline. Stars indicate points where daily oiling is advised. Other parts, marked by letters, should be greased every three hours when running steadily.

Waste can be prevented in many ways. They will depend to a large extent on the design of the equipment, the product being handled, the duty involved and the location. Frequently slight changes in design may solve the problem.



Courtesy of The Vilter Manufacturing Co.

Fig. 5—Constructional details of the Vilter rotary refrigerating compressor. Attention is drawn to the manner of sealing cylinder, and roller bearing mounting for the rotor. Lubricating oil serves a dual function of cooling the compressor and lubrication.

In the steel mill, for example, especially on certain older types of equipment, gears and bearings are sometimes inadequately protected from the scale, dust, dirt and water which may come in contact with such moving parts.

It has been proved, however, that gears can be enclosed in sheet metal housings, and bearing guards installed which will materially reduce the extent to which lubricants can be contaminated. By this prevention of contamination the durability and life of such products can be extended, with marked results in economy.

The lubricating engineer, therefore, should study design from this point of view. He may, however, not always be able to prevail on his accounts to spend the money for such means of protection. It is then his duty to decide upon grades of lubricants commensurate with the existing operating conditions.

To prepare a theoretical lubrication recommendation for any specific type of machine, however, is more or less of an ideal, for normally it would be based upon modern design and the assumption that the builders have realized the importance of lubrication and the necessity for protecting the moving parts as much as possible. For instance, whereas a very high grade product such as a filtered mineral oil would be adaptable to such a type of design, where an older installation is involved, the engineer should use his judgment in substituting a product which, from a price point of view, will be in line with the existing conditions.

A working lubrication recommendation should include two or more grades of lubricants of varying degree of refinement; where oils are involved, however, they should be of approximately the same viscosity, commensurate with speed, operating pressure and the extent to which temperature variation may occur.

The operator should, in turn, realize this when in the market for such lubricants. If he is dealing with a representative of a reputable oil company these facts will be brought to his attention, the proper viscosity or body of the lubricant decided upon, and the choice between a primary and secondary grade of lubricant justified according to the operating conditions of the installation.

Necessity for Primary Inspection

After a piece of machinery has been installed and been in operation for a certain length of time, it is generally advisable to make a primary inspection of the lubricating system.

From the lubricating engineer's point of view, primary inspection of heavier machinery or equipment pertinent to an entire production process, should be made with the full cooperation of the installation engineer of the machinery builder. The routine to follow requires consideration of alignment, bearing clearances, the provisions made to prevent entry of water or non-lubricating foreign matter, the adaptability of the lubricating equipment to the operating requirements, the location and the accessibility of distributing piping and control fittings.

Lubricant control and the assurance that the lubricating system can be depended upon positively to deliver the required amount of oil or grease to the moving parts of the machinery in question is absolutely essential. In making primary inspection this should never be lost sight of, for no matter how perfect the bearings, piston ring fit or sealing devices, if there is any possibility of impaired flow or distribution of lubricant, serious wear may develop at any time, to cause disruption of production schedules and require costly repair.

Where force-feed circulating oiling systems are involved, such an inspection will be particularly advantageous, for initial operation will always tend to lead to the accumulation of

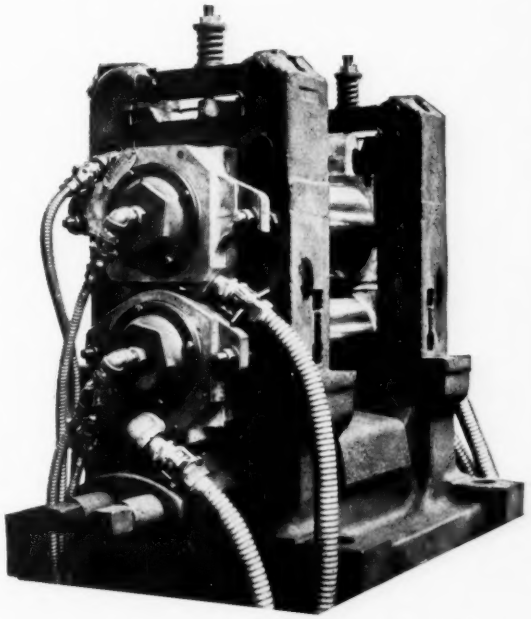
a certain amount of non-lubricating, foreign matter, just as holds true in the automotive engine when it is new. Such foreign matter may be composed of core sand, or fine metallic particles developed during the wearing-in period. If the lubricant is circulated in sufficient volume under adequate pressure, or periodically delivered under comparatively high pressure, there will be but little tendency for such foreign matter to accumulate within bearing clearances or oil grooves. Where grease is employed, such materials will, in all probability, be forced out through the ends of the bearings. In the average oiling system, however, such foreign matter will normally be carried back to the base reservoir or oil supply tank, from which it can be removed at the cleaning period. In view of the fact that such accumulations may be excessive during the running-in period, cleaning should be carefully carried out at the time of primary inspection.

There is more to this matter of primary inspection, however, than removal of non-lubricating, foreign matter. As mentioned above, it should also include study of bearings, to check any tendency toward misalignment. The possible entry of water should also be carefully checked. It is important to remember that the presence of water, in company with metallic particles, may lead to development of sludge formation. This is most distinctly objectionable in the case of steam turbine operation. On the other hand, it should not be allowed to occur wherever it can be prevented, for it is the forerunner of impaired lubrication and clogging of the lubricating system.

The amount of time which will be involved in making a primary inspection will, of course, depend upon the type of machine in question. The paper machine, for example, by virtue of the wide variety of bearings employed, the presence of water and paper pulp, as well as the comparatively high temperatures which exist on the drier end of the machine, should be given very careful attention. In this machine, alignment is one of the most important factors pertinent to continued and satisfactory operation. Bearing wear, particularly where plain bearings are involved, should be studied with the utmost care. Other equipment, however, such as the steam pump or reduction gear set, would entail only inspection of the cylinder walls or gear teeth to make sure that the proper amount of lubricant is being delivered to prevent scoring, scuffing or abnormal wear.

The value of primary inspection has been evidenced in connection with a recent Diesel engine installation, following the development of abnormal oil consumption after renewal of piston rings. Cursory examination of the crankcase gave no indication of abnormal vaporization, nor was there any evidence of inadequate lubrication, or formation of serious carbon deposits.

With the realization that installation of new piston rings might give rise to a certain amount of leakage until they are worn to a running fit, the surface of the rings was studied, to observe whether they might be installed upside down, with the sharp edge tending to scrape oil up into the combustion chamber. With this thought in view, the rings were reversed. The results were extremely gratifying. Immediately after the engine was put back into service the oil consumption dropped from around 12 gallons per day to 6 gallons.



Courtesy of Morgan Construction Company

Fig. 6—End view of a Morgan steel rolling mill, equipped with an improved type of sleeve type, roll neck bearing, designed for connection to the oil circulating system. An advantage claimed for this bearing is its unit construction, which facilitates removal without exposing bearing surfaces to mill dirt or scale.

As a general rule it is impracticable entirely to tear down a piece of machinery to make such an inspection. Where time and cost will permit, however, it would normally be advantageous, in view of the extent to which future trouble might be prevented and the life of the machine increased.

A distinctly interesting example of the part played by the inspection engineer in getting a machine properly installed, accurately aligned and ready for subsequent operation and lubrication without necessity for over-haul, has been recently evidenced in one of the largest paper manufacturing plants in the south. In this instance the machine was ready for production

half an hour after starting up and showed absolutely no misalignment.

OPERATING FACTORS

The relation of operating conditions to machine design and ultimately successful lubrication should be as fully understood by the designing engineer as by the installation and lubricating engineers. Speed, pressure and temperature, coupled with the possibility, in some cases, of entry of non-lubricating, foreign matter, should be of particular interest. There will frequently be more or less of a relation between speed and pressure, just as there may be between pressure and temperature. Normally, higher speeds will be accompanied by comparatively low pressures. Of equal interest is the fact that higher pressures may involve higher bearing temperatures. It is unwise to set up empirical rules or limits covering the above, however, for every machine will be more or less individual in its make-up.

Speed

Where speed alone is considered, it will generally be practicable from a lubricating point of view, to vary the viscosity or lubricant body inversely with the speed. In other words, for high speed conditions a comparatively light bodied lubricant can be used. Lower speeds will require a heavier product.

It should be understood that the reason for this is that the higher the speed the greater will be the degree to which the lubricant will be drawn into the clearance spaces by capillary action. The development of a constant film of lubricant within the bearing clearance space, however, will of course be contingent upon the extent to which automatic lubrication is maintained. Obviously if oil is delivered by means of a drip feed oiler, wherein the principle is to supply just enough oil to maintain lubrication, increase in speed, unless the rate of drip of oil is increased, may result in impaired lubrication. This is an important detail for the designer to remember in planning the means of lubrication.

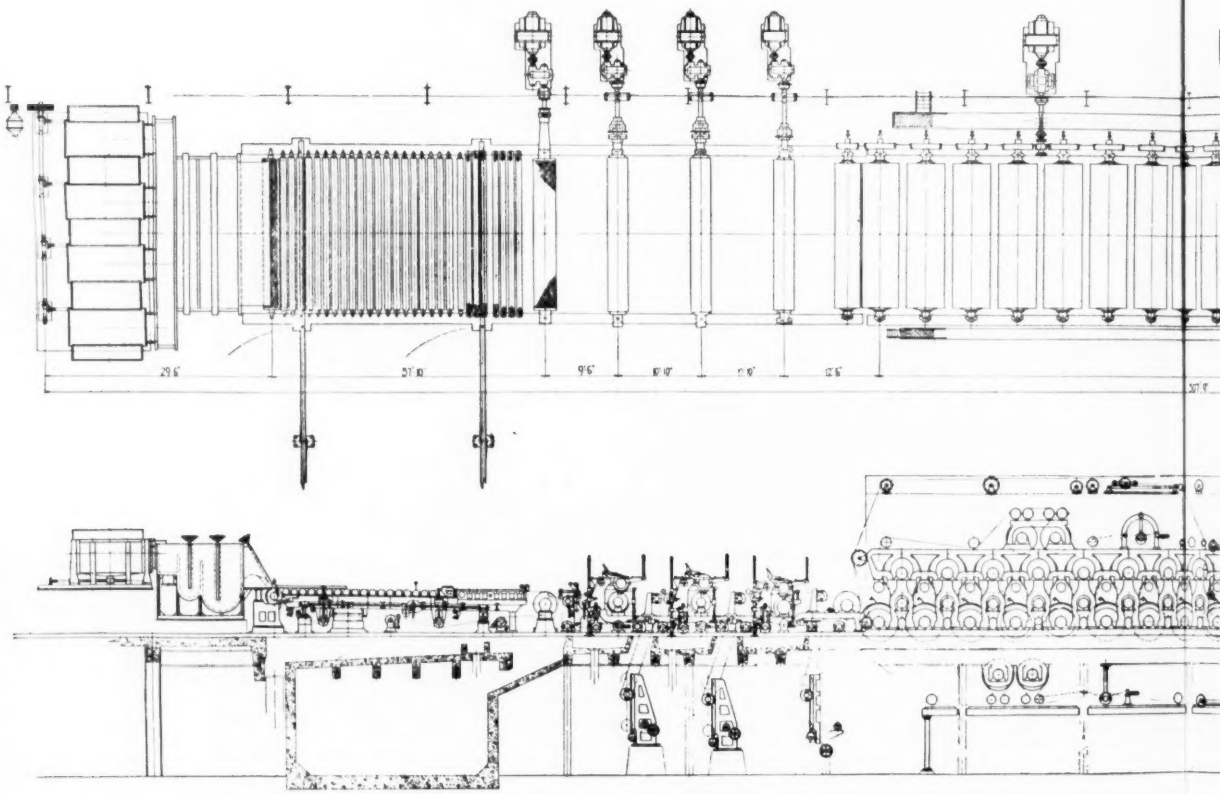


Fig. 7—Plan and elevation views of a modern paper machine, showing wet end, drier roll construction and calenders. Automatic lubrication in connection with ant

The Advantage of Flood Lubrication

On the other hand, where automatic lubrication of the force feed type is involved, there will often be more oil delivered than is required to maintain lubrication. Flood lubrication, also, will tend materially to resist the effects of pressure. This is admirably illustrated

by the lubricating system of the average pressure oiled steam turbine bearing. Here, although comparatively high speeds may be involved, and bearing pressures may be fairly high, if the oil is delivered under from 8 to 15 pounds pressure a product of as low a viscosity as 140 seconds Saybolt at 100 degrees Fahr., will adequately maintain lubrication and insure protection of the bearings.

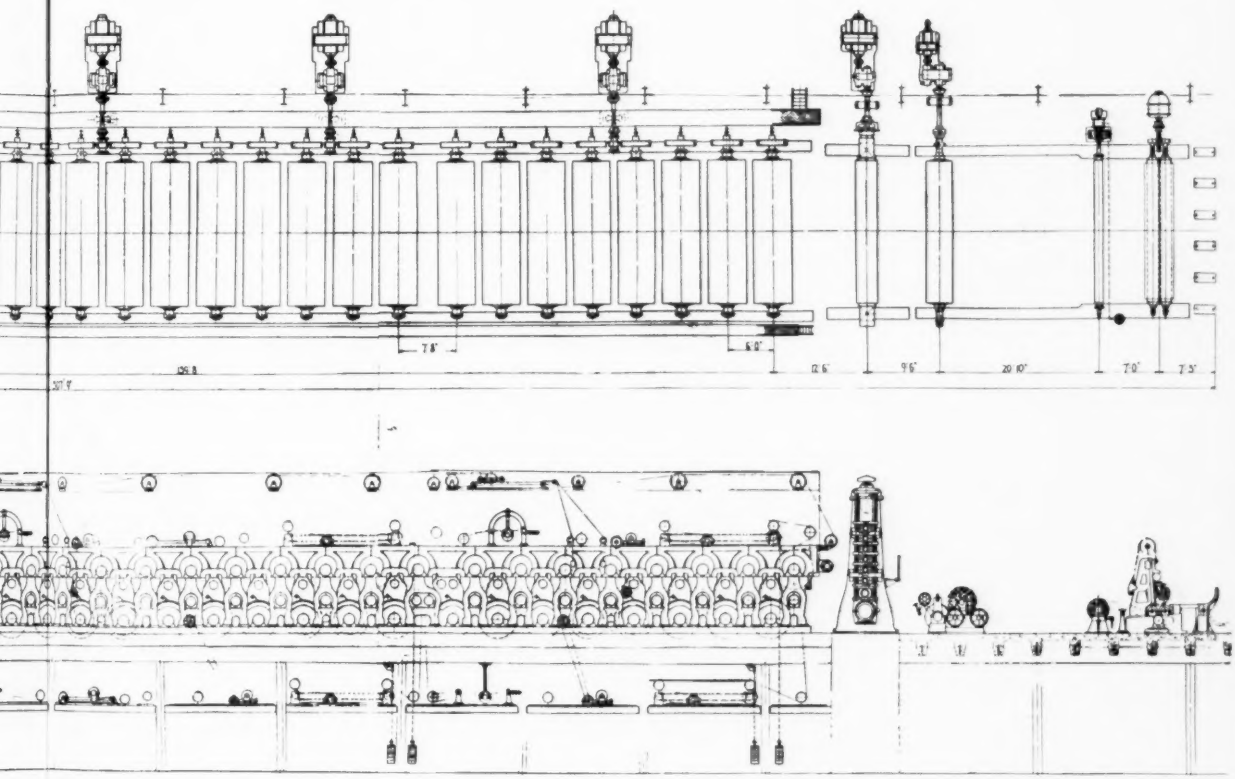
The grinding machine is another device where flood lubrication of the high speed elements has been proved to be essential and an effective aid to the development of speeds as high as 15,000 R.P.M. With both these machines lubrication must be given most careful thought during both the designing and installation stages.

Flood lubrication possesses another advantage in that the excess oil passing through the bearings will remove a certain amount of the heat developed during operation, or received from an external source. This is noteworthy in connection with the operation of calender stacks in the paper industry. As a result, it may be said that speed leads to the development of a more positive lubricating film, due to the increased capillary action, or the extent to which the oil is drawn into bearing clearances. It also makes possible the use of a lighter product, which will oftentimes reduce the amount of power consumed as well as the amount of internal friction developed within the body of the lubricant.

In planning for use of grease in connection with high speed conditions, it is well to remember that such products are more particularly adaptable to anti-friction bearing construction. It has been proved that if the bearing is properly designed to retain the lubricant, and a product chosen with a high degree of protective ability, it will insure lubrication for an extensive period of operation, with the necessity for renewal perhaps only three to four times a year.

An anti-friction bearing should never be completely filled with lubricant, for this may not only lead to channelling of the product, but also to increased power consumption, due to the drag which may be imposed upon the rolling elements. It may also lead to difficult starting in cold weather.

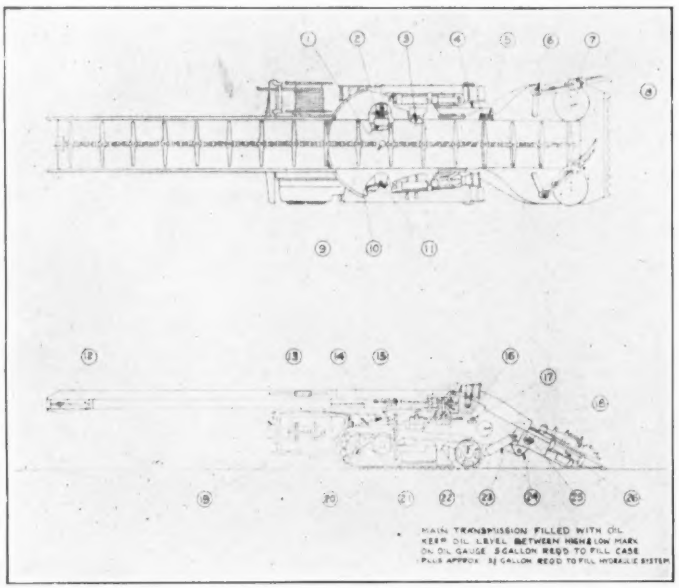
In connection with gears, chains or other motions, speed must be studied from the viewpoint of the extent to which centrifugal force will be developed and the lubricant thrown



Courtesy of The Pusey and Jones Corporation

ction with anti-friction bearings has been extensively adopted on this type of machine, to the marked advantage of the operator and productive ability of the machine.

from the moving parts. Here, therefore, there is more relationship between speed and the adhesive characteristics of the lubricants. This will be especially true on exposed gears or chains. For this reason, the designing engineer


MAIN TRANSMISSION FILLED WITH OIL
KEEP OIL LEVEL BETWEEN HIGH & LOW MARK
ON OIL GAUGE 5 GALLON REQD TO FILL CASE
PLUS APPROX. 3½ GALLON REQD TO FILL HYDRAULIC SYSTEM

Courtesy of Joy Manufacturing Company

Fig. 8—Lubrication diagram for a mechanical coal loader of the 8 BU Joy type. Manufacturer's instructions relative to the number key give operator adequate information as to lubrication requirements.

should study the practicability of using proper housings.

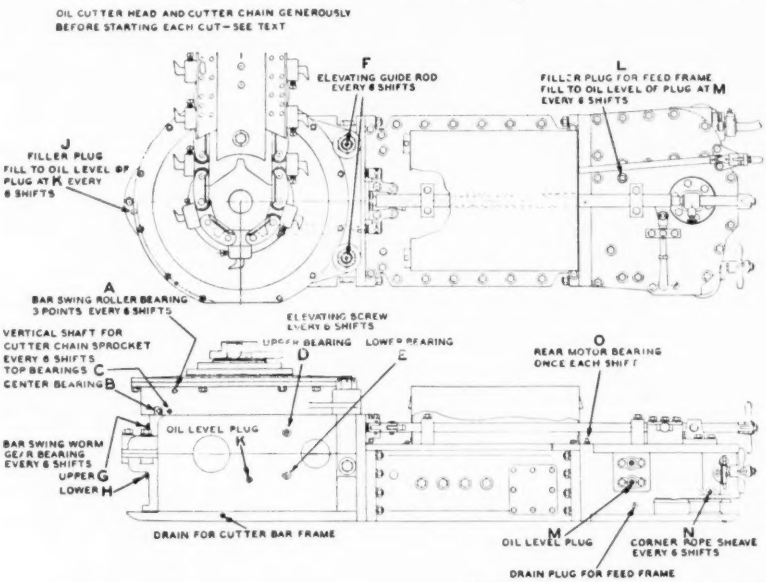
In an oil-tight gear or chain housing a comparatively fluid oil can be used, especially if it is automatically delivered to the parts and not merely carried to these by virtue of the dipping of the gear or chain sprockets in the bath of lubricant.

Where gears and chains are not tightly housed, however, thought must be given to the adhesive characteristics as well as the viscosity of the lubricant. It is for this reason that straight mineral petroleum products are more adaptable to such installations than compounds such as greases. This is an important item which should be borne in mind, particularly by the installation engineer.

Certain types of cylinder stock greases will have comparatively high adhesive tendencies. On the other hand, they will be more expensive and not as resistant to water conditions as the straight mineral residual gear lubricants. Here again it is within the province of the lubricating and installation engineers to study the conditions and make their recommendations jointly, explaining to the operator the reasons for determining how heavy a product should be used, after due consideration of construction, size and the probable gear tooth pressures.

Effect of Pressure

Pressure must be considered virtually from the first drafting room layout of the average industrial machine, due to its relation to the size of the component moving parts. The installation and lubricating engineers, however, are concerned with pressure on account of the effect which it may have upon the performance of lubricants and life of bearings or gear teeth. Considering lubrication, one must remember that if the viscosity or consistency of the lubricant is not sufficient to withstand any squeezing out action which may be developed due to the construction of the moving parts, considerable damage will probably follow, because of lack of proper lubrication. As a result, pressure is one of the salient factors which must be considered in the study of any lubricating problem,

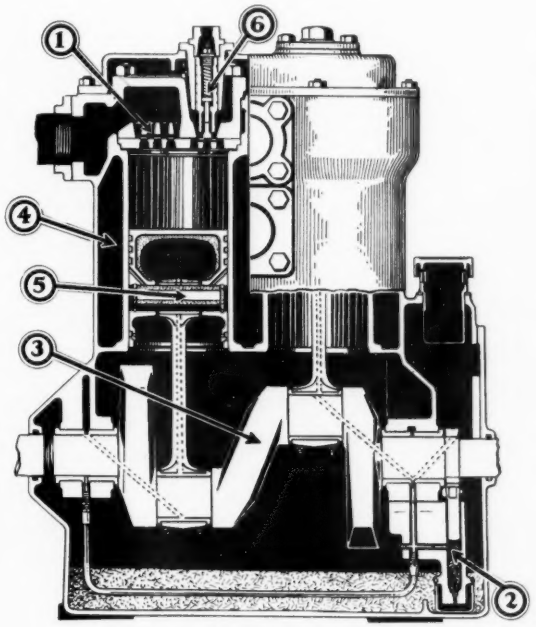

OIL CUTTER HEAD AND CUTTER CHAIN GENEROUSLY BEFORE STARTING EACH CUT—SEE TEXT
F
ELEVATING GUIDE ROD EVERY 6 SHIFTS
L
FILLER PLUG FOR FEED FRAME FILL TO OIL LEVEL OF PLUG AT M EVERY 6 SHIFTS
J
FILLER PLUG FILL TO OIL LEVEL OF PLUG AT K EVERY 6 SHIFTS
A
BAR SWING ROLLER BEARING 3 POINTS EVERY 6 SHIFTS
ELEVATING SCREW EVERY 6 SHIFTS
VERTICAL SHAFT FOR CUTTER CHAIN SPROCKET EVERY 6 SHIFTS
TOP BEARINGS C
CENTER BEARING B
UPPER BEARING D
LOWER BEARING E
O
REAR MOTOR BEARING ONCE EACH SHIFT
OIL LEVEL PLUG K
BAR SWING WORM GEAR BEARING EVERY 6 SHIFTS
UPPER G
LOWER H
DRAIN FOR CUTTER BAR FRAME
M
OIL LEVEL PLUG
N
CORNER ROPE SHEAVE EVERY 6 SHIFTS
DRAIN PLUG FOR FEED FRAME

Courtesy of Sullivan Machinery Company

Fig. 9—Showing lubrication chart of a Sullivan coal cutting machine, with adequate reference to parts requiring lubrication, and advice pertaining to same.

prior to deciding upon the proper type of lubricant to use.

In this connection, pressure must be viewed from two angles, viz.: static and operating. The former, as developed by virtue of the dead



Courtesy of The Worthington Pump and Machinery Co.

Fig. 10—Constructional view of a Worthington compressor showing at 1, patented Worthington Feather Valve; 2, full force feed lubrication by direct plunger pump on crankshaft; 3, drop forged, counter-balanced crankshaft; 4, cooling system; 5, four-ring auto type piston with full floating wrist pin; 6, bronze plunger unloader, fitted with two piston rings to eliminate air leakage during unloading period.

weight or stationary load, particularly on bearings, may be decidedly serious.

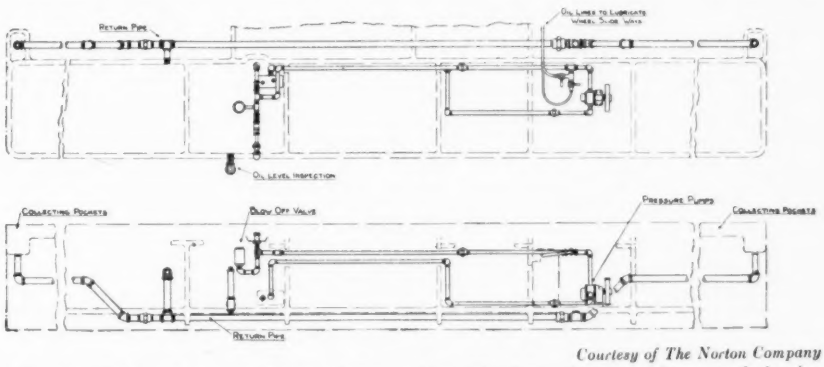
Experience in starting calender stacks in the paper industry, has indicated the importance of lubrication. On such machines the weight carried by the bottom roll is enormous, varying from 30 to 50 tons, or even somewhat higher.

It is the practice of certain authorities in paper mill design and operation to recommend starting the rolls one at a time. Starting of these rolls will become increasingly difficult from the bottom up, due to the fact that the weight of each is carried by its companion roll. The bearings of such rolls, serve only as a means of maintaining alignment. Generally they carry a very small proportion of the load.

Because the accumulated weight is carried on the bottom roll bearings, there will be a tendency for the oil to be almost entirely squeezed out from the clearance spaces when the stack is shut down. Experience has indicated that cutting cross grooves in the bottom bearing of the bottom roll, with provision for direct connection to an auxiliary oil pipe at the point of intersection of these grooves, will enable the use of an auxiliary hand pump. With this device it is possible to pump a supply of oil into the clearance space and virtually raise the journals from actual metal-to-metal contact with the bearings. This has been found to reduce static friction to a marked degree and enable comparatively easy starting of the entire stack.

Under average conditions the greater the operating pressure between any two wearing elements, the heavier or more viscous must be the lubricating film in order to prevent metal-to-metal contact. This holds true whether bearings, gear teeth or chain link connections are involved. The normal effect of pressure will be a tendency toward squeezing out of the lubricating film from between the wearing surfaces. In a bearing the essential solution to this problem will be adequate bearing area and proper grooving.

Danger of impaired lubrication due to operating pressure can be further reduced by enclosed construction, and operating the parts in a bath or flood of lubricant. Relative to the development of such pressures, however, it must be remembered that the period of maximum in-

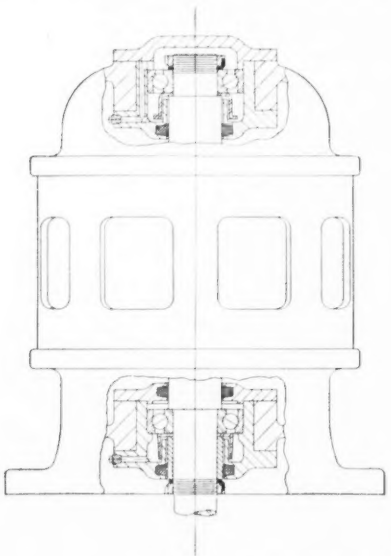


Courtesy of The Norton Company

Fig. 11—Oil piping diagram of a Norton grinding machine. Oil is delivered by a geared pump to the bearing ways and grooves, which serve to distribute the oil over the entire length of the base and the ways. Excess oil is returned through a filter to the oil reservoir prior to re-circulation.

tensity may be relatively brief, as for example in the operation of a metal press.

In other cases, pressure can be met with pressure, the lubricant being maintained within the clearance spaces under the prevailing pressure of some form of pumping device. This, however, calls for a relatively tight lubricating system throughout.



Courtesy of Standard Steel and Bearings, Inc.

Fig. 12—Showing a vertical electric motor mounting, arranged for oil lubrication. By virtue of the design, both upper and lower bearings are continually furnished with an adequate supply of oil.

Controlling Conditions

Whatever the method of lubrication, however, a certain degree of adhesiveness and sufficient viscosity must be prevailing characteristics of the lubricant itself. To make any other than generalized statements as to the viscosity range would be unwise. Too much will depend upon construction, operation and means of application. It will be far better to make a primary study of these conditions in order that the severity of the duty may be realized. With such knowledge as a basis, and an understanding of what is actually involved when the terms viscosity or body are used, the problem of subsequently selecting suitable lubricants should be materially simplified and successful operation later assured.

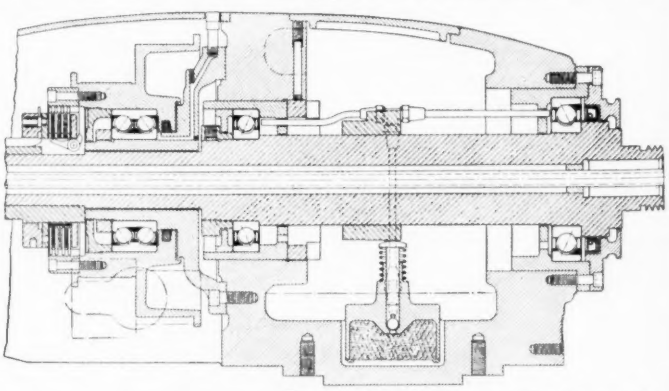
The ultimate factor in deciding whether to use oil or grease will be the type of lubricating equipment provided and the operating conditions such as speed and bearing pressures, and details of construction, such as manner of grooving. The size, duty and bulky nature of the moving parts of the average machine involving high pressures has rendered it advisable in many cases to provide for some form of positive, automatic lubrication. Greater convenience should thereby result, with frequently marked savings in labor, due to reduction in the amount of attention necessary.

Typical examples of this nature will be rolling equipment in the steel mill, the metal press in the automotive plant, the milling machine, the cement kiln and the textile press.

Operating Pressure

Wherever pressure may prevail in machinery operations, it is important to remember that the "operating pressure" should be given primary consideration. When the rolling mill or metal press, for example, is idling, the pressure which may exist between the teeth of its gear trains or upon the bearings of certain of its shafting may not be abnormal. When idling there should, therefore, be no serious lubrication problem.

Under operation, however, the pressure to be exerted upon the raw materials in the formation of finished or semi-finished products may be so severe as to cause a reaction pressure back through practically all the moving elements of the machine. Not with the same intensity in every case, to be sure, for this will depend upon the size or relative importance of the parts involved. Such reactionary or back pressures, on the other hand, will be considerably in excess of the idling pressures, and hence they will be a potential cause of lubricating difficulties and the development of abnormal wear.



Courtesy of The New Departure Manufacturing Co.

Fig. 13—Showing an internal grinder head spindle, equipped with ball bearings. The double row bearings are grease lubricated. The single bearings are automatically oil lubricated by oil under pressure, which is passed through a wool felt filter during circulation

In the selection of lubricants to meet such conditions, one should give prior consideration

to the body and adhesive ability in order that the product may be able effectively to withstand being squeezed out from between gear teeth, chain link connections, or bearings and shafting. These characteristics in the lubricants must be regarded from the viewpoint of maximum pressure involved, even though this may result in abnormal internal friction within some lubricants when certain types of machinery may be idling. It is far more important to prevent metal-to-metal contact, however, under high operating pressures and thereby preclude the development of abnormal wear, than to reduce power consumption during idling. This is especially true inasmuch as such machinery to develop maximum efficiency should idle as little as possible during the working day.

Viscosity Indicative of Cohesive Ability

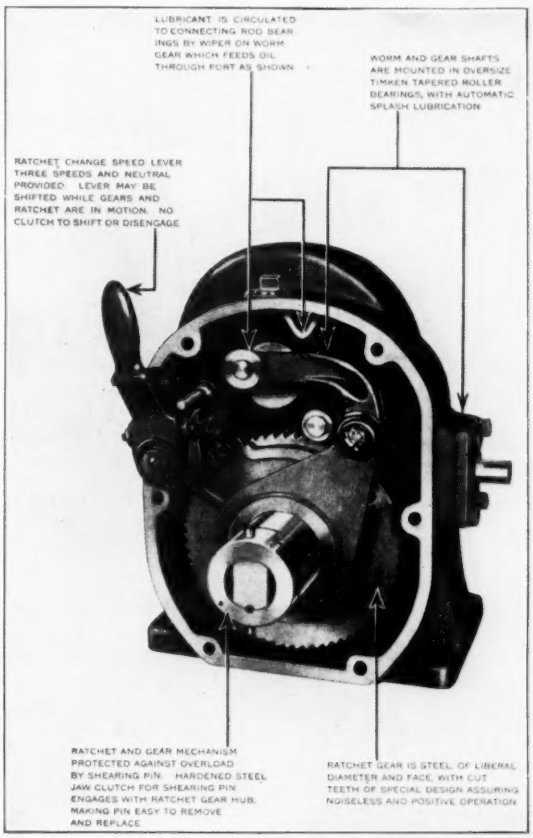
Viscosity as a factor in the selection of lubricants for service under high operating pressures must be thoroughly understood by both the designer and the installation engineer. Viscosity being a measure of the relative fluidity of a lubricant indicates the body of the latter. Practically speaking, this means its ability to withstand the squeezing out effects of pressure, by virtue of the cohesion between its component molecules. In a grease the viscosity of the oil content is the controlling factor, the consistency being more a measure of the soap content.

Certain research in regard to the relation of viscosity to pressure has dealt with pressure as applied to lubricants within a space of definite limitations. Rarely will such conditions hold true in actual operation, for it is difficult to build the lubricating system so tight in the average heavy duty machine.

Where it is practicable, however, to build a pressure lubricated bearing virtually oil tight, one may assume that the lubricant will be subjected to mechanical pressure at a rate exceeding its tendency to leak or pass from the bearing, to assure positive lubrication and load carrying capacity to a marked degree. Research of certain investigators has indicated that under such conditions the effects of pressure within the clearance spaces may be similar to those caused by temperature reduction at normal atmospheric pressure, the result being increase in the viscosity of the oil.

Unless this occurs to an extreme, effective lubrication will be promoted for the existing oil film will be compressed and rendered more capable of preventing metal-to-metal contact. Lack of adequate fluidity must not result, for this would mean that certain parts of the bearing might not receive sufficient oil.

On most machinery, however, which will be subjected to heavy bearing or gear tooth pressures, the lubricating film will have some place to go. In other words, whereas high mechanical pressure may be involved, the lubricant will still be exposed to atmospheric pressure at the ends of bearings or sides of gear teeth. In consequence, the extent to which it will continuously maintain a lubricating film of adequate thickness will depend upon its ability to resist being squeezed out.


LUBRICANT IS CIRCULATED TO CONNECTING ROD BEARINGS BY WIPER ON WORM GEAR WHICH FEEDS OIL THROUGH PORT AS SHOWN
WORM AND GEAR SHAFTS ARE MOUNTED IN OVERSIZE TIMKEN TAPERED ROLLER BEARINGS, WITH AUTOMATIC SPLASH LUBRICATION
RATCHET CHANGE SPEED LEVER THREE SPEEDS AND NEUTRAL PROVIDED. LEVER MAY BE SHIFTED WHILE GEARS AND RATCHET ARE IN MOTION. NO CLUTCH TO SHIFT OR DISENGAGE
RATCHET AND GEAR MECHANISM PROTECTED AGAINST OVERLOAD BY SHEARING PIN. HARDENED STEEL JAW CLUTCH FOR SHEARING PIN ENGAGES WITH RATCHET GEAR HUB. MAKING PIN EASY TO REMOVE AND REPLACE
RATCHET GEAR IS STEEL OF LIBERAL DIAMETER AND FACE, WITH CUT TEETH OF SPECIAL DESIGN ASSURING NOISELESS AND POSITIVE OPERATION

Courtesy of Link-Belt Company

Fig. 14—Constructional details of a Link-Belt variable speed stoker drive, with notes pertinent to lubrication.

Influence of Temperature

Temperature will have a bearing upon a lubrication recommendation wherever the operating temperatures may vary. As a general rule, this factor must be considered in deciding not only upon the means of lubrication, but also, later, in studying the manner of preparation of a grease and the melting point of any such product, or the viscosity of an oil, whereever conditions may be deemed to be in any way abnormal.

High temperature conditions will usually impose a greater duty upon a lubricant than any other phase of operation. In connection with this matter of temperature, it must be remembered that the inherent possibility of

development of solid friction will always be present. Solid friction between any two surfaces in motion with respect to one another implies the presence of heat, which is invariably developed by the occurrence of friction. It is the function of lubrication to eliminate solid or metallic friction, supplementing it with fluid friction.

Viscosity or body of a lubricant must be given the most careful attention wherever high operating temperatures may prevail, for viscosity will vary inversely with temperature. The higher the operating temperature the greater will be the tendency for the body or viscosity of the lubricant to be reduced. If the original viscosity is not sufficiently high to allow for this reduction, the increased fluidity may lead to impairment of the lubricating film to such an extent as actually to cause metal-to-metal contact. This will be especially apt to occur under comparatively high pressure. The viscosity-temperature conversion chart, therefore, should be studied in connection with the formulation of a lubrication recommendation for high temperature operation. By the use of such a chart one can readily determine the operating viscosity of any lubricating oil or the oil content of a grease at the prevailing temperature of operation, knowing the viscosity at some two points such as 100 degrees and 210 degrees Fahr., according to the prevailing marketing specifications. Normally lubricating oils of a viscosity up to approximately 800 seconds Saybolt at 100 degrees are specified at this particular temperature. The viscosity of heavier lubricants, however, is usually stated at 210 degrees Fahr.

The use of an oil of sufficient viscosity to meet the operating conditions will not only result in more effective lubrication, but it will also prove of decided value in reducing the amount of power or energy required to move the working elements. In addition, any tendency towards the development of abnormal frictional heat will be reduced. All this will lead to improved lubrication, for it will enable the oil to perform its function more perfectly, by virtue of its viscosity or body, maintaining the proper lubricating film under all conditions.

Relation of Viscosity

The fact that viscosity varies inversely with the temperature is an asset, for it will often permit the use of one lubricant for a number of points of varying external temperatures, provided the size of the wearing elements and the pressure exerted are taken into account when the lubricant is originally selected. The mistake should never be made of regarding the viscosity at say 100 degrees Fahrenheit as of sole importance, for an oil which might be of adequate viscosity at that temperature might be too light to meet an operating temperature range at say 150 degrees Fahrenheit.

Inasmuch as "operating viscosity" plays so important a part in this matter of high temperature lubrication, a detailed knowledge of viscosity in general will be advisable.

Just what is meant by the statement that an oil should have a viscosity of, let us say, 500 seconds Saybolt at 100 degrees Fahrenheit may be vague to some. It is well, therefore, to mention that this means at a uniform temperature of 100 degrees Fahrenheit it will take 60 c.c. of the oil in question 500 seconds to flow through the orifice of the standard Saybolt viscosimeter.

Viscosity, therefore, is an indication of the relative fluidity of an oil at the temperature of test, being that inherent property by virtue of which the flow of liquids is retarded, through the resistance offered by the particles or molecules in sliding past each other.

The operating viscosity of an oil is equally as important where low temperatures are involved as when high temperatures prevail. In case of low temperature operation, however, there will be less possibility of metal-to-metal contact between the wearing elements. Under such conditions we must be more concerned with the possibility of developing abnormal internal friction within the body of the lubricating film itself. This would, of course, lead to increased power consumption. If allowed to become abnormal it might even render the machine inoperative. There would also be the difficulty of delivering such a sluggish lubricant to the moving parts on starting. Should this occur for any length of time, metal-to-metal contact might develop until the temperature of the moving parts is raised sufficiently to thin down the lubricant and cause it to flow more or less readily.

Melting point is a factor where a grease is involved. Here the operating temperatures must be given careful consideration. There are certain types of greases, of course, which by virtue of their soap content, method of manufacture and the nature of refinement of the oil used, will have a much lower melting point than others. Cup greases, for example, will show a melting point of around 200 degrees Fahrenheit. Cylinder stock or soda soap products, however, can be compounded to show a melting point of considerably above 300 degrees, yet the penetration or consistency may be very much the same. A cup grease should not be heated above its melting point, or even within the vicinity of same, for any length of time, due to the possibility of evaporation of its normal water content and alteration of the homogeneity. This would be indicated by separation of the oil from the soap.

Printed in U. S. A. by
EDGAR C. RUWE CO., INC.
72 Washington St., N. Y. C.